Thinner and Thinner Asphalt Layers for Maintenance of French Roads

J. BELLANGER, Y. BROSSEAUD, AND J. L. GOURDON

Very thin and ultrathin wearing courses of coated materials have occurred because of changes in pavement construction and maintenance policy; in the ever-higher level of service offered to users; in formulations, following the use of binders modified by adding polymers or mineral or organic fibers; and in the technology of placement.

Thin-layer techniques are used extensively on the French road network. The most widely used by far is the chip seal (CS), of which more than 100 million m^2 is applied every year. Cold mixes are used steadily with limited success; approximately 8 million square meters are applied a year. Some techniques, such as repaving and thermorecycling, have never caught on; others, such as thin hot-mix asphalt with chippings and coated sands with chippings, are in decline. Very thin (20 to 25 mm) and ultrathin (10 to 15 mm) wearing courses of coated materials have experienced very rapid growth in the past few years.

Because of their small or very small thicknesses (less than 40 mm), very thin surface layers (VTSLs) and ultrathin hot-mix asphalt layers (UTHMALs) are normally used on pavements that need neither structural strengthening nor major correction of evenness. They are basically maintenance techniques, but some of them are occasionally used for the wearing courses of new or overlaid pavements.

VTSLs and free-draining surface layers are also used in new wearing courses, preceded by a base course of coated materials 40 to 60 mm thick, when special care must be taken with the surface characteristics of the pavement (comfort and skidding resistance) and when it is judged that one thick layer would not attain the assigned objectives.

COMPARATIVE CHARACTERISTICS OF VTSLs AND UTHMALs

VTSLs and UTHMALs are among the most promising techniques in terms of a compromise among comfort, safety, and inconvenience to users. The UTHMAL technique is a development of the VTSL technique, midway between it and the chip seal. These three techniques will be compared in the following sections.

J. Bellanger, Laboratoire Régional des Ponts et Chaussées d'Angers, Avenue de L'Amiral Chauvin, BP 69, Les Ponts-de-Ce-Cedex 49136, France. Y. Brosseaud and J. L. Gourdon, Laboratoire Central des Ponts et Chaussées, 58 boulevard Lefebvre, F 75732, Paris cedex 15, France.

Formulation

The most common grading is 0/10 mm with a 2/6-mm gap. Gap-graded 0/6-mm formulations are also used in VTSLs and, less often, in UTHMALs. This finer grading is applied mainly in urban settings; the resulting texture is a good compromise between skid resistance and tire-pavement contact noise. There are very few gap-graded 0/14-mm formulations; they are used only in VTSLs because of their tendency to segregate when spread manually. The difference between VTSLs and UTHMALs lies in the percentage of coarse aggregate and the proportion of binder. For example, an intermediate 0/10-mm formulation for VTSL is 65 to 70 percent 6/10-mm and 5.8 to 6.0 weight percent binder; for UTHMAL, it is 75 to 80 percent 6/10 and 5.2 to 5.6 weight percent binder.

The fines content (undersized at 0.080 mm) is generally between 6 and 9 percent for both techniques. The binder is most often a pure distilled 60/70 (occasionally 80/100) penetration grade asphalt.

To improve the mechanical properties and resistance to climatic stresses, additives (polymer or fibers) are often incorporated. These special formulations account for 90 percent of VTSL applications. The criterion generally used in deciding whether to use these formulations is heavy traffic. It is thought that for more than 1,000 trucks/day/direction, it is best to use a modified binder to ensure greater cohesion and a more lasting macrotexture.

The special processes use, in most cases, asphalts modified by synthetic polymers such as styrene butadiene styrene (SBS) or ethylene and vinyl acetate or polymers recovered from recycled rubber powder. These give the binder very good elastomeric properties and make it less sensitive to temperature variations. They also use, to a lesser extent (15 percent of the technique), mineral or organic fibers—from 0.3 to 1.2 percent, according to type. These fibers make it possible to use a larger proportion of asphalt (6.4 to 6.8 weight percent binder) and structure the asphaltic mastic.

Study of Formulation

Existing laboratory tests are poorly suited to products applied in very small thicknesses, because the UTHMAL technique tends toward a monogranular surfacing that is more like a chip seal than a coated material. However, it is possible to characterize trends in the evolution of VTSLs in the laboratory. The tests required by the French standard in the context of formulation studies cover the following:

- Resistance to removal of the coating by water;
- Workability of the VTSL as determined by the density obtained in the Laboratoire Central des Ponts et Chaussées (LCPC) gyratory shear press; and
- Durability of the macrotexture of the surfacing, evaluated by a traffic simulation using the LCPC rutting tester. The change in texture depth by sand patch test (TD) is measured on the sample.

The standard also calls for on-site inspection of the macrotexture, with specific TD values of at least 0.8 mm for a 0/10 and 0.6 mm for a 0/6.

Production

The materials can be produced in all types of coating plants: continuous, batch, or dryer drum mixer. Their preparation requires few special precautions other than observance of the proper aggregate drying temperatures. Contrary to what might be thought, VTSL and UTHMAL are not subject to segregation during transport or spreading because of the low proportion of sand and the large discontinuity. Because their formulations are close to that of porous asphalt, they have a similar appearance after placement. The surfacing is very uniform and the longitudinal joints are practically invisible, giving a very attractive appearance.

Placement

Besides their slightly different formulations, placement is where the VTSL and UTHMAL techniques differ. VTSLs are applied with a normal plant: a conventional paver preceded by a binder spreader. The tack coat is applied, according to the condition of the substrate, at between 0.4 and 0.7 kg/m^2 emulsion, often modified. This cost is essential to the process. It provides the bonding and sealing that the surfacing alone cannot provide because of the overly large percentage of voids (about 10 percent). The spreading speed is 5 to 8 m/min. Compaction is done with steel-wheeled rollers.

Because of the need to spread a substantial tack-sealing coat, 0.8 to 1.0 kg/m^2 emulsion, a special plant must be designed for the simultaneous high-speed spreading of the two layers of the complex in a UTHMAL. This layer consists of an emulsion, modified by latex or an SBS copolymer, giving this layer—the quality of which determines the properties of the surfacing—very good elasticity, cohesion, and adhesion. The plant must include

- A tack coat spreader bar having a flow rate controlled by forward speed and an adjustable width, with associated storage tanks to give the machine adequate capacity between refillings;
- A storage compartment for the coated aggregates to prevent cooling and allow nonstop spreading; and
- A variable-width system for distributing and leveling the coated aggregates.

Its operating characteristics include

- A width of 2.5 to 4.2 m (5.0 m for one of the machines), and
- A working speed always greater than 10 m/min that routinely reaches 20 to 25 m/min.

With this equipment, the three application operations (spreading of binder, coated gravel, smoothing-compaction) follow one another rapidly. This leads to

- Optimal bonding of the coated aggregates to the layer of binder and to one another (no gravel is sprayed when the road is reopened to traffic);
- A clean job;
- Rapid completion of the maintenance work and much less inconvenience to users. The site occupies a length of only 300 to 400 m; traffic resumes immediately after the end of rolling, accomplished by two or three passes of the steel-wheeled roller (one of the contractors recommends using a rubber-tired compactor for finishing). This compaction work in the surfacing is limited to an area of 150 m behind the paver.

COMPARISON OF MAIN PROPERTIES OF CSs, VTSLs, AND UTHMALs

Macrotexture

Assessed by the sand patch method, the ranges of macrotexture measured at sites are given in Table 1. Semigranular (SG) 60 mm thick is included for comparison. The measurements show that macrotexture holds up well in VTSLs and UTHMALs but that in CSs, which have the greatest initial sand height, it deteriorates quickly under high traffic, by indentation into the substrate. However, CSs still have the highest values. Additionally, the type of macrotexture differs according to the placement process;

- CS has a macrotexture "in relief" because of the method of spreading the coarse aggregate and because of compaction by a rubber-tired compactor;
- VTSL has a "flat" macrotexture because of smoothing by a paver screed and compaction by a steel-wheeled roller, which tend to force the coarse aggregate embedded in the asphaltic mortar into a flat position; and
- UTHMAL has an intermediate macrotexture because the smaller quantity of asphaltic mortar leaves the coarse aggregate some freedom of placement, despite light compaction by a smooth roller.

TABLE 1 MACROTEXTURE MEASUREMENTS

	Initial Thickness (mm)	Thickness After 1 Yr of Traffic (mm)
VTSL 0/10	1.0–1.2	0.9–1.0
VTSL 0/6	0.8–1.0	0.8–0.9
UTHMAL 0/10	1.7–2.0	1.3–1.9
CS 0/6	2.5–3.0	1.6–2.2
SG 0/10	0.5–0.7	0.4–0.5

Skid Resistance

Skid resistance is assessed using the coefficient of longitudinal friction (CLF), between 40 and 120 km/hr (smooth tire, locked wheel). The three techniques compared are among the best of all French road surfaces: CLF at 40 km/hr is very good and similar for these three techniques (about 0.5 CLF). It maintains for high speeds (about 0.40 CLF at 120 km/hr), especially for UTHMAL, even though it must be corrected for the younger age of the surfaces tested.

Tire-Pavement Contact Noise

Measurements of tire-pavement contact noise outside the vehicle at 90 km/hr were made on modern thin layers and compared with chip seal noise under comparable conditions. In this way it was shown that a VTSL had a noise level close to that of conventional coated materials, on the order of 74 dB(A), and lower than that of chip seals at the same site [77 to 80 dB(A)]. A recent comparison of a 0/10-mm UTHMAL and a 6/10-mm chip seal using a slightly different measurement method (Franco-German protocol) has also revealed a significant difference [repeatability is 1 dB(A)] in favor of the UTHMAL [77 dB(A) against 80 dB(A) for the chip seal] that can be detected by a human as a doubling of the noise level [+3 dB(A) is equal to a doubling of the noise level].

Impermeability

Impermeability is difficult to measure on site using common means because of the marked macrotexture of very thin layers, which poses problems of tightness around the measurement apparatus. The impermeability of CSs is regarded as very good, thanks to the thick film of binder (1 to 1.7 mm). On VTSLs and UTHMALs, a few measurements of permeability have been made on cores, in the laboratory, at a pressure of 0.3 MPa. For VTSLs, the percentage of voids in the coated materials is high (approximately 12 to 15 percent) and the impermeability is governed by the thickness of the tack coat (0.3 to 0.4 kg/m^2 of residual asphalt). For UTHMALs, laboratory measurements have shown that the tack-sealing coat, at approximately 0.6 kg/m^2 of residual asphalt, ensures good impermeability.

Longitudinal Evenness

By its nature, the chip seal allows no correction of pavement evenness. For VTSLs and UTHMALs, on the other hand, many measurements have been made using the longitudinal profile analyzer (APL). Passes before and after the work show that in most cases, despite the small thickness applied, VTSLs (average thickness 25 mm) and UTHMALs (average thickness 1.5 mm) slightly but really improve the evenness of the pavements on which they are used (improvement is 10 to 25 percent in APL coefficient).

CONCLUSION

In France, VTSL has for 3 or 4 years been an especially powerful and effective maintenance technique that is routinely used to meet the increasingly stringent requirements imposed by growing traffic and higher safety standards. UTHMAL is the ultimate development of the hot-mix technique in the direction of reduced thickness. It is the product of materials and equipment research and of contractors' experience with the tried and tested techniques (CSs and VTSLs) that led up to it. In the surface maintenance of pavements that have suffered little deformation, for all types of traffic, where the use of a layer contributing nothing to the pavement structure is compatible with the long-term maintenance strategy chosen, UTHMAL enables a high level of service at low cost. Its speed of execution and of reopening to traffic, its careful implementation (it does not pollute the environment), its level of comfort and safety, and its very small thickness are its major strengths. The first results meeting a favorable reception by project supervisors and users forecast substantial growth of the UTHMAL technique.

Publication of this paper sponsored by Committee on Pavement Maintenance.